We, RHONE-POULENC CHIMIE, a French Company, of 25, Quai Paul Doumer, 92408, Courbevoie, Cedex, France, hereby apply for the grant of a Standard Patent for an invention entitled:

"PROCESS FOR THE PRODUCTION OF CERIC OXIDE"

which is described in the accompanying Complete Specification.

Details of basic application:

Number: 88/17068
Country: France
Date: 23rd December, 1988

Our address for service is:

SHELSTON WATERS
55 Clarence Street
SYDNEY, N.S.W. 2000.

DATED this 18th Day of December, 1989
RHONE-POULENC CHIMIE

To: The Commissioner of Patents
WODEN A.C.T. 2606

File: D.B. R-61
Fee: $241.00

REPRINT OF RECEIPT
SO12112 20/12/89
COMMONWEALTH OF AUSTRALIA PATENTS ACT, 1952-1973
DECLARATION IN SUPPORT OF A CONVENTION APPLICATION FOR A PATENT

In support of the Convention Application No. .................................................. made
by ..................................... RHONE-POULENC CHIMIE .................................

(hereinafter referred to as “Applicant”) for a patent for an invention entitled:
(b) "PROCESS FOR THE PRODUCTION OF CERIC OXIDE"

(c) and (d) Here Insert Full Name and Address of Company Official authorised to make declaration.

(e) Here Insert Basic County or Countries followed by date or dates of Basic Application(s).

(f) Here Insert Full Name(s) of Applicant(s) in Basic Country.

(g) Here Insert (in full) Name and Address of actual Inventor or Inventors.

1. I am authorised by Applicant to make this declaration on its behalf.

2. The basic Application(s) as defined by section 141 of the Act was/were made
in .................................. FRANCE ...................................on the 23rd day of December, 1988
by .................................. RHONE-POULENC CHIMIE .................................

3. .................................. Jean-Luc LE LOARER of 24, rue du General Guillaumat
70007 LA ROCHELLE, Françoise PICARD of 50, avenue de la Dame Blanche - 94120 FONTENAY/SOUS/BOIS and Claire DAVID of 14BIS, rue Friant - 75014 - PARIS are all of France. They are the actual Inventor(s) of the invention and the facts upon which Applicant is entitled to make the Application are as follows:

Applicant is the Assignee of the said Inventor(s).

4. The basic Application(s) referred to in paragraph 2 of this Declaration was/were the first Application(s) made in a Convention country in respect of the invention, the subject of the Application.

DECLARED at .................................. COURBEVOIE ..................................
this .................................. 6TH day of NOVEMBER 1989 ..................................

(m) Personal Signature of Declarant (c) (no seal, witness or legalisation).

To THE COMMISSIONER OF PATENTS.

SHELSTON WATERS
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It has a specific surface area included between 160 and 15 m²/g measured following calcination at a temperature included between 350 and 900°C.
PROCESS FOR THE PRODUCTION OF CERIC OXIDE

Introducing into a sealed vessel, a colloidal dispersion of a compound of cerium IV obtained by reacting an aqueous solution of a salt of cerium IV with a base so as to obtain a neutralisation rate greater than 0 and lower than 4.0,

- heating the said medium to a temperature and pressure lower than the critical temperature and pressure, respectively, of the latter,

- cooling the reaction medium and bringing it back to atmospheric pressure,

- separating the precipitate formed,

- then calcinating it.
The following statement is a full description of this invention, including the best method of performing it known to us:-

"PROCESS FOR THE PRODUCTION OF CERIC OXIDE"
PROCESS FOR THE PRODUCTION OF CERIC OXIDE

The present invention pertains to a novel process for the production of a ceric oxide with a large specific surface area at high temperature.

In the specification of the invention that follows is meant by specific surface area the specific surface area B.E.T., determined by nitrogen adsorption in accordance with the standard ASTM D 3663-78, based on the method BRUNAUER - EMMETT - TELLER described in the periodical "The Journal of American Society, 60, 309 (1938)".

It is known that ceric oxide can be used as catalyst or as a substrate for catalyst. One may mention, for instance, the work of Paul MERIAUDA and colleagues in relation to the synthesis of methanol, starting from CO + H₂, on platinum catalysts deposited onto ceric oxide (C.R. Acad. Sc. Paris, Vol. 297 - Series II-471-1983).

It is also well known that the effectiveness of a catalyst usually increases as the surface area of contact between the catalyst and the reagents becomes larger. To this end, it is necessary that the catalyst remains in as divided a state as possible, i.e. that the solid particles which comprise it be as small and distinct as possible. The fundamental role of the substrate is therefore to keep the catalyst particles or crystallites in contact with the reagents, in as divided a state as possible.

During prolonged use of a catalyst substrate, a reduction of the specific surface area occurs as a result of the coalescence of the very fine micropores. During this coalescence, a fraction of the catalyst is engulfed within the mass of the substrate, and is therefore no longer in contact with the reagents.

Up to now, most of the ceric oxides prepared exhibit a specific surface area which rapidly decreases at working temperatures higher than 500°C. Thus, R. ALVERO and colleagues (J. Chem. Soc. Dalton Trans. 1984, 87) obtained, starting from ammonium cerinitrate, a ceric oxide exhibiting, following calcination at a temperature of 600°C, a specific surface area of 29 m²/g.

Furthermore, a ceric oxide exhibiting a specific surface area of at least 85 ± 5 m²/g following calcination between 350 and 450°C and, preferably, included between 100 and 130 m²/g following calcination between 400 and 450°C, was described in FR-A 2 559 754. The said oxide is prepared by hydrolysis of an aqueous solution of ceric nitrate in acid nitric medium, then by separation of the precipitate obtained, washing with an organic solvent, possibly drying, then calcination. The ceric oxide obtained exhibits an interesting specific surface area when it is prepared within a calcination temperature range of 300 to 600°C.
However, following calcination at a higher temperature, a drop of the specific surface area is seen, the latter being 10 m²/g following calcination at 800°C.

FR-A 2 559 755 may also be mentioned. It pertains to a ceric oxide exhibiting a specific surface area of at least 85 ± 5 m²/g following calcination between 350 and 500°C and, preferably, included between 150 and 180 m²/g following calcination between 400 and 450°C. This oxide is obtained according to a process which consists of precipitating a basic ceric sulphate by reacting an aqueous solution of ceric nitrate with an aqueous solution containing sulphate ions, of separating the precipitate obtained, washing it by means of a solution of ammonia, possibly drying it then calcinating it at a temperature varying between 300 and 500°C. The ceric oxide thus prepared exhibits a large specific surface area, but when subjected to calcination at 800°C, its specific surface area decreases extensively, and is close to 10 m²/g.

In the European patent application n° 88 401593.4, the Applicant described a process to increase and stabilise, at high temperature, the specific surface area of a ceric oxide.

This process consists of subjecting ceric hydroxide, precursor of ceric oxide, to a solvothermal treatment prior to the operation of calcination.

More particularly, the process described in the said application consists of:
- suspending the ceric hydroxide in a liquid medium,
- heating it within a sealed vessel to a temperature and a pressure below the critical temperature and critical pressure of the said medium, respectively,
- cooling the reaction medium and bringing it back to atmospheric pressure,
- separating the ceric hydroxide so treated,
- then calcinating it.

By ceric hydroxide is meant hydrated ceric oxide CeO₂·2H₂O or else a ceric hydroxide possibly containing residual amounts of bound or adsorbed anions such as, for instance, chlorides, sulphates, nitrates, acetates, formiates, etc...

A preferred operative mode of the process described in European patent application n° 88 401593.4 consists of using a solution of base as autoclaving liquid medium.

Such a process permits not only the increase of the specific surface area of the ceric oxide obtained, but also the conservation of a high specific surface area at temperatures up to 900°C.

By subjecting a ceric hydroxide prepared by reacting a solution of cerium salt and a base possibly in the presence of an oxidizing agent, under pH conditions above 7, to autoclaving in basic medium, the Applicant proposes according to European patent application n° 88 401594.2, a ceric oxide presenting a specific surface area, at 800-900°C, never reached by the products described within the state of the art.

The ceric oxide thus obtained has a specific surface area of at least 15 m²/g measured following calcination at a temperature between 800 and 900°C and, preferably, included between 20 and 60 m²/g measured following calcination at a temperature of 800°C.
It has a specific surface area included between 160 and 15 m²/g measured following calcination at a temperature included between 350 and 900°C.

Thus it can exhibit a specific surface area varying between 70 and 160 m²/g and, preferably, between 100 and 160 m²/g following calcination at 350 and 450°C.

However, when subjected to a higher temperature possibly reaching 900°C, at the time of its use, especially in the field of catalysis, it has the characteristic of retaining a specific surface area of at least 15 m²/g and, preferably, included between 20 and 60 m²/g when subjected to a temperature of 800°C.

In the present application, the specific surface areas that are indicated are measured on a product having undergone a calcination of at least 2 hours at the given temperature.

Another characteristic of the ceric oxide, subject of European patent application no. 88 401594.2, is to exhibit a porous volume that is greater than 0,1 cm³/g at a measuring temperature between 800 and 900°C and, preferably, greater than 0,15 cm³/g.

The porous volume corresponding to pores of a diameter smaller than 60 nm (600 Å) is measured with a mercury porosimeter according to the standard ASTM D4284-83, or following the method of nitrogen adsorption isotherms, the aforementioned B.E.T. method.

Like the specific surface area, the porous volume is dependent on the calcination temperature: it can vary between 0,35 and 0,15 cm³/g for a calcination temperature ranging from 350 to 900°C.

The preferred ceric oxide, subject of European patent application no. 88 401594.2, has a porous volume included between 0,15 and 0,25 cm³/g following calcination at a temperature of 800°C.

The pore size of a ceric oxide calcinated at 800°C ranges from 3 nm (30 Å) and 60 nm (600 Å); the pore mean diameter d_{50} varies between 20 nm (200 Å) and 30 nm (300 Å), and is preferably around 25 nm (250 Å).

The mean diameter is defined as being a diameter such that all pores under this diameter constitute 50 % of the total porous volume (Vp) of the pores of diameter below 60 nm (60 Å).

A ceric oxide calcinated at 350°C has pores of 2 nm (20 Å) to 100 nm (1000 Å); the mean diameter varying from 10 nm (100 Å) to 20 nm (200 Å) and, preferably, close to 15 nm (150 Å).

X-ray diffraction analysis shows that the ceric oxide subject of European patent application no. 88 401594.2 has a crystalline phase of CeO₂ type, with a mesh size varying from 0.542 nm (5,42 Å) to 0.544 nm (5,44 Å). By way of indication, it shall be specified that the size of the crystallites from a ceric oxide obtained following calcination at 350°C lies between 4 nm (40 Å) and 6 nm (60 Å) and following calcination at 800°C, between 10 nm (100 Å) and 20 nm (200 Å).

It has now been discovered that a ceric oxide displaying such morphological characteristics could be obtained according to another preparation process, starting not from...
ceric hydroxide, but from a colloidal dispersion of a ceric hydroxide obtained directly from a salt of cerium IV.

The precise object of the present invention is therefore a process for the production of a ceric oxide exhibiting a specific surface area of at least 15 m²/g following calcination at a temperature between 800°C and 900°C, characterised by the fact that it consists of:

- introducing into a sealed vessel a colloidal dispersion of a compound of cerium IV obtained by reacting an aqueous solution of a salt of cerium IV with a base so as to obtain a rate of neutralisation greater than 0 and lower than 4.0,
- heating the said medium to a temperature and pressure below the critical temperature and pressure, respectively, of the latter,
- cooling the reaction medium and bringing it back to atmospheric pressure,
- separating the precipitate that is formed,
- then calcinating it.

In accordance with the invention process, a colloidal dispersion of a compound of cerium IV is used. The latter is the subject of patent applications EP-A 0 206 906 and EP-A 0 208 580, which are incorporated for reference in the present specification.

By colloidal dispersion of a compound of cerium IV is meant a colloidal dispersion of ceric hydroxide or hydrated ceric oxide CeO₂·2H₂O possibly containing residual amounts of bound or adsorbed ions such as, for example, nitrate, ammonium.

The preparation of the said colloidal dispersion is achieved by reacting a cerium IV salt aqueous solution with a base under the conditions described below.

A quantity of base that is lower than that required for full neutralisation of the cerium IV present in the reaction medium to obtain Ce(OH)₄ is used.

As a result, cerium IV is obtained not in the form of a gelatinous precipitate, but in the form of colloids, meaning that there is presence of particles of colloidal dimensions.

According to the conditions of preparation of the said dispersion, the cerium IV can be totally in the form of colloids. It is also possible for the cerium IV to be simultaneously in the form of ions and in the form of colloids. To simplify the account, one means by "colloidal dispersion" a colloidal dispersion as well as an ion-colloid mixture: the latter will be better explained later on.

By way of cerium IV salt solutions, one can use in particular an aqueous solution of ceric nitrate or an aqueous solution of ceri-ammoniacal nitrate. The said solution may contain cerium in the cerous state without disadvantage, but it is desirable that it contains at least 85 % of cerium IV.

The concentration of the cerium salt solution is not critical, according to the invention. When expressed as cerium IV, it may vary between 0.1 and 2 moles per liter: a concentration between 0.1 and 1 mole per liter is preferred.
The aqueous solution of cerium IV salt usually has a certain initial acidity and may have a normality varying between 0,1 and 4 N. The H⁺ ion concentration is not critical. A concentration lying between 0,1 N and 1 N is desirable.

The solution of ceric nitrate obtained according to the process of electrolytic oxidation of a solution of cerous nitrate, which is described in French patent application FR-A 2 570 087 (n° 84 13641) constitutes a raw material of choice.

The basic solution used according to the invention process may be, in particular, an aqueous solution of ammonia, soda or potash. It is also possible to use gaseous ammonia. According to the invention, a solution of ammonia is preferred.

The normality of the basic solution used is not critical according to the invention, and may vary within large limits, for instance between 0,1 and 11 N, but preferably between 0,1 and 5 N.

The proportion of basic solution to cerium IV salt solution must be such that the rate of neutralisation is greater than 0 and lower than 4,0. It is preferably between 0,1 and 3,8, and still more preferably between 0,5 and 3,0.

The neutralisation rate r is defined by the following equation:

\[ r = \frac{n_3 - n_2}{n_1} \]

where:
- \( n_1 \) represents the number of moles of Ce IV present in the final colloidal dispersion
- \( n_2 \) represents the number of moles of OH⁻ required to neutralise the acidity brought by the aqueous solution of salt of cerium IV
- \( n_3 \) represents the total number of moles of OH⁻ brought by the addition of base.

The neutralisation rate reflects the colloidal state of the cerium IV:
- when \( r = 4 \), the cerium IV precipitates in gelatinous form
- when \( r = 0 \), the cerium IV is in ionic form
- when \( 0 < r < 4 \), the cerium IV is in ionic and/or colloidal form.

When the neutralisation rate is high, i.e. greater than 3,0, the cerium IV in the colloidal dispersion obtained is mainly in the form of colloids. For neutralisation rates between 3,4 and 3,8, the proportion of cerium IV in colloidal form is 100 %

In the case of high neutralisation rates, the colloids have a chemical composition which corresponds to formula (I):

\[ \text{Ce(OH)}_{4-x} \left( \text{NO}_3 \right)_x \] (I)

where \( x \) varies between 0,3 and 0,7.

It should be noted that ionic strength is important in view of the presence of a high concentration of the salt of the base, which is between 0,3 and 8 moles/liter.
When the neutralisation rate is lower than or equal to 3.0, the proportion of cerium IV in colloidal form is between 10 and 90% of the cerium IV used.

The reaction between the aqueous solution of the salt of cerium IV and the base used in the previously defined quantities is performed at a temperature which may vary between 0°C and 60°C, but preferably at room temperature (most often 15 to 25°C).

The aforementioned reagents may be mixed according to several variants. For example, one may proceed to the simultaneous mixing of the aqueous solution of the cerium IV salt and of the basic solution, under agitation, or else add, continuously or all in one, the base into the aqueous solution of the cerium IV salt, or vice versa.

Mixing time is not critical and depends upon the capacity of the equipment. It may vary between 0.1 second and 30 hours.

Whatever the sequence in which the reagents are introduced, a colloidal dispersion of a compound of cerium IV in aqueous medium is obtained, dispersion which can then be implemented within the invention process.

The concentration of the colloidal dispersion of a compound of cerium IV, expressed as CeO₂, can vary between 0.1 and 2.0 moles/liter, preferably between 0.1 and 1.0 mole/liter.

The mean hydrodynamic diameter of the colloids varies between 4 nm (40 Å) and approximately 40 nm (400 Å). It is determined by light quasi elastic scattering according to the method described by Michael. L. McConnell in Analytical Chemistry, 53, no° 5, 1007A (1981).

In accordance with the process for producing a ceric oxide with a large specific surface area according to the invention, the said dispersion is subjected to autoclaving.

The autoclaving operation is performed at a temperature between the reflux temperature and the critical temperature of the reaction mixture. A temperature between 100°C and 350°C is preferred, and even more so between 150°C and 350°C.

The speed at which the temperature is raised is not critical. The reaction temperature is reached by heating between 30 minutes and 4 hours, for instance.

The invention process may be carried out by introducing the colloidal dispersion of ceric hydroxide into a sealed vessel, the pressure therefore only results from heating the reaction medium.

Under the temperature conditions given above, and in aqueous medium, it can be specified, by way of indication, that the pressure varies between 1 (10⁵ Pa) and 165 (165.10⁵ Pa), and preferably between 5 (5.10⁵ Pa) and 165 Bars (165.10⁵ Pa).

It is also possible to apply an external pressure which would then add to that resulting from heating.

The duration of the autoclaving operation is not critical. It may vary between 30 minutes and 6 hours.

At the end of the latter, the system is left to cool under its inertia, and brought back to atmospheric pressure.
The product in suspension in the liquid medium is separated according to conventional solid-liquid separation techniques such as decantation, blotting, filtration and/or centrifugation.

The product recovered may eventually be washed, preferably with water, and/or dried. Drying may be performed in air or under reduced pressure, for example of the order of 1 to 100 mm of mercury (133,322 Pa to 13332,2 Pa). The drying temperature may vary between room temperature and 100°C, and the drying time is not critical and may vary between 2 and 48 hours.

According to a last step of the invention process, the product obtained is calcinated at a temperature between 300°C and 1000°C and, preferably, selected between 350°C and 800°C. Calcination time may vary within large limits, between 30 minutes and 10 hours, and preferably between 2 and 6 hours.

It can be verified that, according to the invention, autoclaving of a colloidal dispersion of ceric hydroxide such as defined permits the production of a ceric oxide displaying a high specific surface area of at least 15 m²/g following calcination at a temperature between 800°C and 900°C. The specific surface area of the ceric oxide obtained varies, in general, between 20 and 60 m²/g and, more particularly, between 20 and 35 m²/g, following calcination at a temperature of 800°C.

The following Examples illustrate the invention without, however, limiting it.

**EXAMPLES 1 TO 3**

1. Preparation of the colloidal dispersion of ceric hydroxide

   In this series of tests, a colloidal dispersion of ceric hydroxide with the following neutralisation rates is used: \( r = 0,5 \) (Example 1), \( r = 1,5 \) (Example 2), \( r = 3,0 \) (Example 3).

   One starts from an aqueous solution of ceric nitrate containing 1,25 moles/liter of cerium IV, 0,02 mole/liter of cerium III and a free acidity of 0,35 N, prepared by electrolysis in accordance with FR-A 2 570 087.

   An aqueous solution of ammonia (3N) is added, at the rate of 0,5 mole of OH⁻ per mole of CeO₂ and per hour: the amount of base added being calculated so that the desired neutralisation rate is obtained.

   In all the Examples, the colloidal dispersion of ceric hydroxide obtained is more precisely a colloidal dispersion of a ceric hydroxinitrate having a molar ratio \([\text{Ce IV}]/[\text{NO}_3^-] = 0,5\) and its concentration, expressed as CeO₂, is equal to 60 g/l.

   The percentage of cerium in the colloidal form is approximately 15 % in Example 1, 40 % in Example 2 and 90 % in Example 3: It is determined by measuring cerium IV in the
supernatant solution obtained following ultracentrifugation (140,000 g - 2 hours) by potentiometric titration with a titrated solution of iron II.

The mean hydrodynamic diameter of the colloids, measured by light quasi elastic scattering, is 5 nm.

2. Autoclave treatment

In a glass BUCHI reactor equipped with a stirrer working at a speed of 80 rpm are introduced 500 cm$^3$ of the colloidal dispersion prepared in 1.

The reaction medium is autoclaved at a temperature of 180°C, i.e. approximately 12 bars, for 4 hours.

At the end of this thermal treatment, the precipitate is filtered on Buchner.

It is then calcinated for a period of 6 hours at various temperatures: 350°C, 600°C, 800°C.

The results are summarised in the following Table I.

<table>
<thead>
<tr>
<th>Example</th>
<th>$r$-neutralisation rate</th>
<th>Specific surface area ($m^2/g$)</th>
<th>Calcination temperature 350°C</th>
<th>Calcination temperature 600°C</th>
<th>Calcination temperature 800°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$r = 0.5$</td>
<td>90</td>
<td>70</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>$r = 1.5$</td>
<td>96</td>
<td>72</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>$r = 3.0$</td>
<td>80</td>
<td>59</td>
<td>22</td>
<td></td>
</tr>
</tbody>
</table>

It can be seen that the specific surface areas obtained at 800°C are high.
CLAIMS
A process for the production of a ceric oxide exhibiting a specific surface area of at least 15 m²/g following calcination at a temperature between 800°C and 900°C characterised by the fact that it consists of:

- Introducing into a sealed vessel, a colloidal dispersion of a compound of cerium IV obtained by reacting an aqueous solution of a salt of cerium IV with a base so as to obtain a neutralisation rate greater than 0 and lower than 4,0
- Heating the said medium to a temperature and pressure lower than the critical temperature and pressure, respectively, of the latter,
- Cooling the reaction medium and bringing it back to atmospheric pressure,
- Separating the precipitate formed,
- Then calcinating it.

2. Process according to claim 1 characterised by the fact that the colloidal dispersion of a compound of cerium IV is prepared by reacting an aqueous solution of ceric nitrate or ceriammoniacal nitrate with a base.

3. Process according to claim 2 characterised by the fact that the aqueous solution of cerium IV salt is a solution originating from the electrochemical oxidation of a solution of cerous nitrate.

4. Process according to one of claims 2 and 3 characterised by the fact that the concentration in cerium IV salt, expressed as cerium IV, varies between 0,1 and 2 moles/liter.

5. Process according to one of claims 1 to 2 characterised by the fact that the basic solution is an aqueous solution of ammonia.

6. Process according to claim 5 characterised by the fact that the normality of the basic solution is between 0,1 and 5 N.

7. Process according to claim 1 characterised by the fact that an aqueous solution of cerium IV salt is reacted with a base so as to obtain a neutralisation rate included between 0,1 and 3,8.

8. Process according to claim 8 characterised by the fact that a neutralisation rate included between 0,5 and 3,0 is chosen.
9. Process according to claim 1 characterised by the fact that the temperature of reaction between the aqueous solution of cerium IV salt and the base is room temperature.

10. Process according to one of claims 1 to 9 characterised by the fact that one proceeds to the simultaneous mixing of the aqueous solution of cerium IV salt and of the basic solution or that one adds the base into the solution of cerium IV, or vice versa.

11. Process according to one of claims 1 to 10 characterised by the fact that the concentration of the colloidal dispersion of the compound of cerium IV, expressed as CeO₂, varies between 0.1 and 2.0 moles/liter.

12. Process according to claim 11 characterised by the fact that the said concentration is between 0.1 and 1.0 mole/liter.

13. Process according to one of claims 1 to 12 characterised by the fact that the autoclaving temperature varies between 100 and 350°C.

14. Process according to claim 13 characterised by the fact that the said temperature is between 150 and 350°C.

15. Process according to one of claims 1 to 14 characterised by the fact that the pressure varies between 1 (10⁵ Pa) and 165 bars (165.10⁵ Pa).

16. Process according to claim 15 characterised by the fact that the said pressure is between 5 (10⁵ Pa) and 165 bars (165.10⁵ Pa).

17. Process according to one of claims 1 to 16 characterised by the fact that the autoclaving time varies between 30 minutes and 6 hours.

18. Process according to one of claims 1 to 17 characterised by the fact that the calcination temperature lies between 300 and 1000°C.

19. Process according to claim 18 characterised by the fact that the said temperature lies between 350 and 800°C.

20. Process according to one of claims 18 and 19 characterised by the fact that the calcination time varies between 2 and 6 hours.
21. A process for the production of ceric oxide substantially as herein described with reference to the accompanying drawings.

DATED this 18th Day of December, 1989

RHONE-POULENC CHIMIE

Attorney: IAN ERNST
Fellow Institute of Australian of Engineers of Melbourne